

International Geomagnetic Reference Field Revision 1987

IAGA Division I Working Group 1 (D. R. Barraclough, Chairman)

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The International Geomagnetic Reference Field (IGRF) is a series of mathematical models of the main geomagnetic field and its secular variation, the models consisting of sets of spherical harmonic (or Gauss) coefficients. The IGRF has become a widely used means of deriving values of the geomagnetic field components in, for example, studies of magnetic anomalies and investigations of charged particle motions in the ionosphere and the magnetosphere.

Since the adoption of the first IGRF (IGRF 1965) by the International Association of Geomagnetism and Aeronomy (IAGA) in 1968 (IAGA Commission 2 Working Group 4, 1969), the IGRF has been revised four times, to give: the IGRF 1975 (IAGA Division I Study Group on Geomagnetic Reference Fields, 1975); the third generation IGRF (IAGA Division I Working Group 1, 1981); the fourth generation IGRF (IAGA Division I Working Group 1, 1985); and the fifth generation IGRF which is the subject of this note. Details of the derivation of the original IGRF have been given by Zmuda (1971); see Peddie (1982) and Barraclough (1987) for descriptions of its development up to 1985.

Working Group 1 (Analysis of the main field and secular variations) of Division I of IAGA considered the latest revision of the IGRF during the Nineteenth General Assembly of the International Union of Geodesy and Geophys (IUGG) held in Vancouver, Canada in 1987 August. It recommended that the fourth generation IGRF be modified by replacing the models for 1945.0, 1950.0, 1955.0 and 1960.0 with a set of four newly derived models for these epochs, and that these new models be designated as definitive IGRFs (DGRFs).

The IGRF now consists of 8 DGRFs spanning the interval 1945.0 to 1980.0 (DGRF 1945, DGRF 1950, DGRF 1955, DGRF 1960, DGRF 1965, DGRF 1970, DGRF 1975 and DGRF 1980); an IGRF for the interval 1985.0 to 1990.0 (IGRF 1985) consisting of a main-field model for 1985.0 and a predictive secular-variation model for use in adjusting the main-field model to dates between 1985.0 and 1990.0; and a provisional IGRF (PGRF 1980) defined by linear interpolation between the coefficients of DGRF 1980 and IGRF 1985 (main field). All the models for 1965 onwards are identical with the fourth generation IGRF. For dates between the epochs of the DGRFs, linear interpolation between the coefficients of the models on either side of the date is to be used.

Further revision of the DGRFs is not anticipated. The present PGRF 1980 will be superseded when a definitive model of the main field at 1985.0, different from IGRF 1985, is adopted. Present plans are that this will take place at the Twentieth General Assembly of the IUGG in 1991. It is planned to adopt an IGRF for the interval 1990.0 to

1995.0 (IGRF 1990) at the same time, to consist of a main-field model for 1990.0 and a predictive secular-variation model for the interval 1990 to 1995.

The spherical harmonic coefficients for all the constituent models of the IGRF are given in Table 1. The nine main-field models each have 120 coefficients and extend to degree and order 10. The secular-variation model has 80 coefficients and extends to degree and order 8. The coefficients are given in the Schmidt quasi-normal form (Chapman & Bartels, 1940) and refer to a sphere of radius 6371.2 km. When converting between geodetic and geocentric coordinates the use of the IAU ellipsoid (International Astronomical Union, 1966) is recommended; it has an equatorial radius of 6378.160 km and a flattening of 1/298.25.

The coefficients of the IGRF models and computer programs for synthesizing field component values are available from:

World Data Centre C1 for Geomagnetism,
British Geological Survey,
Murchison House,
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World Data Center A for Solid Earth Geophysics,
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World Data Center for Rockets and Satellites,
National Space Science Data Center (Code 630.2),
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The membership of working Group I-1 was: D. R. Barraclough (Chairman), W. Mundt (Vice-Chairman), F. S. Barker, C. E. Barton, V. P. Golovkov, P. J. Hood, F. J. Lowes, N. W. Peddie, Qi Gui-zhong, S. P. Srivastava, D. E. Winch, T. Yukutake and D. P. Zidarov. Valuable assistance was received from: An Chen-chang, R. H. Estes, D. J. Kerridge, R. A. Langel, J. M. Quinn, T. J. Sabaka and J. Verhoef. M. W. McElhinny was Chairman of Division I.

Table 1. The International Geomagnetic Reference Field—fifth generation. Spherical harmonic coefficients of the 9 main-field models, in nT, and of the predictive secular-variation model (SV) for 1985–90, in nT yr⁻¹.

m	n	DGRF								IGRF		
		1945	1950	1955	1960	1965	1970	1975	1980	1985	SV	
g	0	1	-30594	-30554	-30500	-30421	-30334	-30220	-30100	-29992	-29877	23.2
g	1	1	-2285	-2250	-2215	-2169	-2119	-2068	-2013	-1956	-1903	10.0
h	1	1	5810	5815	5820	5791	5776	5737	5675	5604	5497	-24.5
g	0	2	-1244	-1341	-1440	-1555	-1662	-1781	-1902	-1997	-2073	-13.7
g	1	2	2990	2998	3003	3002	2997	3000	3010	3027	3045	3.4
h	1	2	-1702	-1810	-1898	-1967	-2016	-2047	-2067	-2129	-2191	-11.5
g	2	2	1578	1576	1581	1590	1594	1611	1632	1663	1691	7.0
h	2	2	477	381	291	206	114	25	-68	-200	-309	-20.2
g	0	3	1282	1297	1302	1302	1297	1287	1276	1281	1300	5.1
g	1	3	-1834	-1889	-1944	-1992	-2038	-2091	-2144	-2180	-2208	-4.6
h	1	3	-499	-476	-462	-414	-404	-366	-333	-336	-312	5.3
g	2	3	1255	1274	1288	1289	1292	1278	1260	1251	1244	-0.6
h	2	3	186	206	216	224	240	251	262	271	284	2.3
g	3	3	913	896	882	878	856	838	830	833	835	0.1
h	3	3	-11	-46	-83	-130	-165	-196	-223	-252	-296	-10.8
g	0	4	944	954	958	957	957	952	946	938	937	0.1
g	1	4	776	792	796	800	804	800	791	782	780	-0.6
h	1	4	144	136	133	135	148	167	191	212	233	3.8
g	2	4	544	528	510	504	479	461	438	398	363	-7.8
h	2	4	-276	-278	-274	-278	-269	-266	-265	-257	-250	2.2
g	3	4	-421	-408	-397	-394	-390	-395	-405	-419	-426	-1.4
h	3	4	-55	-37	-23	3	13	26	39	53	68	2.5
g	4	4	304	303	290	269	252	234	216	199	169	-6.8
h	4	4	-178	-210	-230	-255	-269	-279	-288	-297	-298	0.9
g	0	5	-253	-240	-229	-222	-219	-216	-218	-218	-215	1.3
g	1	5	346	349	360	362	358	359	356	357	356	0.1
h	1	5	-12	3	15	16	19	26	31	46	47	0.1
g	2	5	194	211	230	242	254	262	264	261	253	-1.5
h	2	5	95	103	110	125	128	139	148	150	148	-0.2
g	3	5	-20	-20	-23	-26	-31	-42	-59	-74	-94	-3.2
h	3	5	-67	-87	-98	-117	-126	-139	-152	-151	-155	-0.1
g	4	5	-142	-147	-152	-156	-157	-160	-159	-162	-161	0.1
h	4	5	-119	-122	-121	-114	-97	-91	-83	-78	-75	0.6
g	5	5	-82	-76	-69	-63	-62	-56	-49	-48	-48	-0.1
h	5	5	82	80	78	81	81	83	88	92	95	0.0
g	0	6	59	54	47	46	45	43	45	48	52	1.4
g	1	6	57	57	57	58	61	64	66	66	65	-0.3
h	1	6	6	-1	-9	-10	-11	-12	-13	-15	-16	-0.4
g	2	6	6	4	3	1	8	15	28	42	50	1.7
h	2	6	100	99	96	99	100	100	99	93	90	-1.1
g	3	6	-246	-247	-247	-237	-228	-212	-198	-192	-186	0.6
h	3	6	16	33	48	60	68	72	75	71	69	-0.8
g	4	6	-25	-16	-8	-1	4	2	1	4	4	0.0
h	4	6	-9	-12	-16	-20	-32	-37	-41	-43	-50	-2.3
g	5	6	21	12	7	-2	1	3	6	14	17	0.9
h	5	6	-16	-12	-12	-11	-8	-6	-4	-2	-4	-0.5
g	6	6	-104	-105	-107	-113	-111	-112	-111	-108	-102	1.2
h	6	6	-39	-30	-24	-17	-7	1	11	17	20	-0.1
g	0	7	70	65	65	67	75	72	71	72	75	0.2
g	1	7	-40	-55	-56	-56	-57	-57	-56	-59	-61	-0.6
h	1	7	-45	-35	-50	-55	-61	-70	-77	-82	-82	0.2
g	2	7	0	2	2	5	4	1	1	2	2	-0.5
h	2	7	-18	-17	-24	-28	-27	-27	-26	-27	-26	1.0
g	3	7	0	1	10	15	13	14	16	21	24	0.8
h	3	7	2	0	-4	-6	-2	-4	-5	-5	-1	1.1
g	4	7	-29	-40	-32	-32	-26	-22	-14	-12	-6	1.0
h	4	7	6	10	8	7	6	8	10	16	23	1.9
g	5	7	-10	-7	-11	-7	-6	-2	0	1	4	0.4
h	5	7	28	36	28	23	26	23	22	18	17	0.3
g	6	7	15	5	9	17	13	13	12	11	9	-0.5
h	6	7	-17	-18	-20	-18	-23	-23	-23	-23	-21	0.2
g	7	7	29	19	18	8	1	-2	-5	-2	0	-0.1
h	7	7	-22	-16	-18	-17	-12	-11	-12	-10	-6	0.9
g	0	8	13	22	11	15	13	14	14	18	21	0.7
g	1	8	7	15	9	6	5	6	6	6	6	0.0
h	1	8	12	5	10	11	7	7	6	7	7	0.1
g	2	8	-8	-4	-6	-4	-4	-2	-1	0	0	0.3
h	2	8	-21	-22	-15	-14	-12	-15	-16	-18	-21	-1.0

Table 1. (Continued)

m	n	DGRF							IGRF	
		1945	1950	1955	1960	1965	1970	1975	1980	1985
g 3	8	-5	-1	-14	-11	-14	-13	-12	-11	-11
g h 3	8	-12	0	5	7	9	6	4	4	5
g 4	8	9	11	6	2	0	-3	-8	-7	-9
g h 4	8	-7	-21	-23	-18	-16	-17	-19	-22	-25
g 5	8	7	15	10	10	8	5	4	4	2
g h 5	8	2	-8	3	4	4	6	6	9	-0.3
g 6	8	-10	-13	-7	-5	-1	0	0	3	11
g h 6	8	18	17	23	23	24	21	18	16	12
g 7	8	7	5	6	10	11	11	10	6	-0.8
g h 7	8	3	-4	-4	1	-3	-6	-10	-13	-16
g 8	8	2	-1	9	8	4	3	1	-1	-6
g h 8	8	-11	-17	-13	-20	-17	-16	-17	-15	-10
g 0	9	5	3	4	4	8	8	7	5	5
g 1	9	-21	-7	9	6	10	10	10	10	10
g h 1	9	-27	-24	-11	-18	-22	-21	-21	-21	-21
g 2	9	1	-1	-4	0	2	2	2	1	1
g h 2	9	17	19	12	12	15	16	16	16	16
g 3	9	-11	-25	-5	-9	-13	-12	-12	-12	-12
g h 3	9	29	12	7	2	7	6	7	9	9
g 4	9	3	10	2	1	10	10	10	9	9
g h 4	9	-9	2	6	0	-4	-4	-4	-5	-5
g 5	9	16	5	4	4	-1	-1	-1	-3	-3
g h 5	9	4	2	-2	-3	-5	-5	-5	-6	-6
g 6	9	-3	-5	1	-1	-1	0	-1	-1	-1
g h 6	9	9	8	10	9	10	10	10	9	9
g 7	9	-4	-2	2	-2	5	3	4	7	7
g h 7	9	6	8	7	8	10	11	11	10	10
g 8	9	-3	3	2	3	1	1	1	2	2
g h 8	9	1	-11	-6	0	-4	-2	-3	-6	-6
g 9	9	-4	8	5	-1	-2	-1	-2	-5	-5
g h 9	9	8	-7	5	5	1	1	1	2	2
g 0	10	-3	-8	-3	1	-2	-3	-3	-4	-4
g 1	10	11	4	-5	-3	-3	-3	-3	-4	-4
g h 1	10	5	13	-4	4	2	1	1	1	1
g 2	10	1	-1	-1	4	2	2	2	2	2
g h 2	10	1	-2	0	1	1	1	1	0	0
g 3	10	2	13	2	0	-5	-5	-5	-5	-5
g h 3	10	-20	-10	-8	0	2	3	3	3	3
g 4	10	-5	-4	-3	-1	-2	-1	-2	-2	-2
g h 4	10	-1	2	-2	2	6	4	4	6	6
g 5	10	-1	4	7	4	4	6	5	5	5
g h 5	10	-6	-3	-4	-5	-4	-4	-4	-4	-4
g 6	10	8	12	4	6	4	4	4	3	3
g h 6	10	6	6	1	1	0	0	-1	0	0
g 7	10	-1	3	-2	1	0	1	1	1	1
g h 7	10	-4	-3	-3	-1	-2	-1	-1	-1	-1
g 8	10	-3	2	6	-1	2	0	0	2	2
g h 8	10	-2	6	7	6	3	3	3	4	4
g 9	10	5	10	-2	2	2	3	3	3	3
g h 9	10	0	11	-1	0	0	1	1	0	0
g 10	10	-2	3	0	0	0	-1	-1	0	0
h 10	10	-2	8	-3	-7	-6	-4	-5	-6	-6

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